Computer Networks

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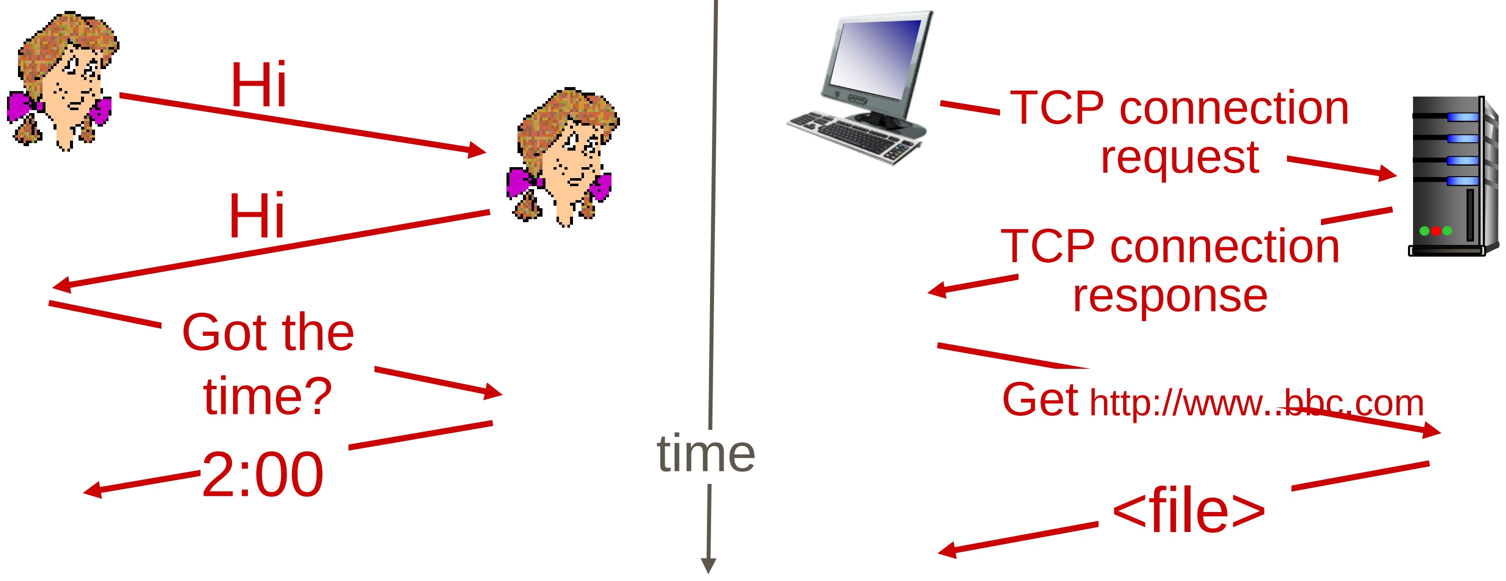
Protocols and Architecture

What’s a protocol?

Set of Rules that define format, order of msgs sent and received among network entities, and actions taken on msg transmission, receipt

a human protocol

a computer network protocol



Hi

Hi

Got the time?

2:00

time

TCP connection request

TCP connection response

Get http://www..bbc.com

<file>

Protocols Characteristics

- Direct or indirect
- Monolithic or structured
- Symmetric or asymmetric
- Standard or nonstandard

Direct or Indirect

- Direct
  - Systems share a point to point link or
  - Systems share a multi-point link
  - Data can pass without intervening active agent
- Indirect
  - Switched networks or
  - Internetworks or internets
  - Data transfer depend on other entities

Monolithic or Structured

- A monolithic protocol is a communication protocol that consists of a single, large software module that handles all aspects of communication between devices.
- However, Communications is a complex task and is too complex for single unit
- Structured design breaks down problem into smaller units
- Layered or Modular Protocol

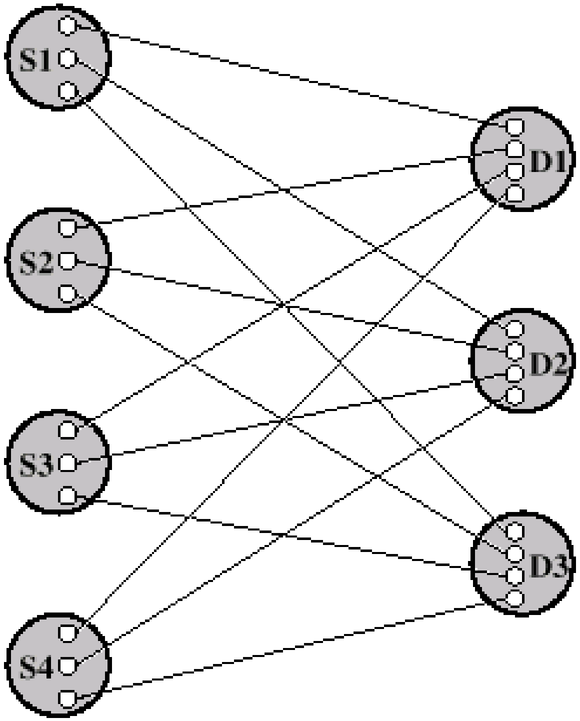
Symmetric or Asymmetric

- Symmetric
  - Communication between peer entities
  - Peer-to-peer (P2P) is a decentralized communications model in which each party has the same capabilities and either party can initiate a communication session.
- Asymmetric
  - Client/server
  - A client-server communication protocol is a set of rules that governs the exchange of data between a client and a server in a networked environment.

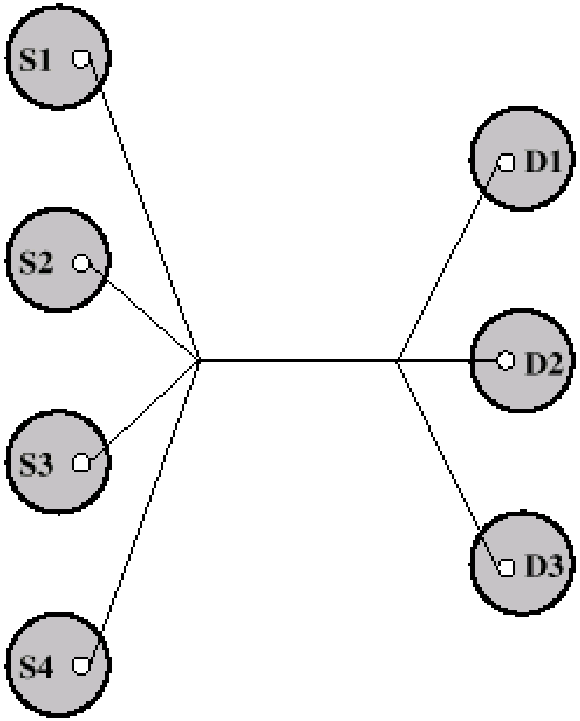
Standard or Nonstandard

- Nonstandard protocols built for specific computers and tasks
- K sources and L receivers leads to K*L protocols and 2*K*L implementations
- If common protocol used, K + L implementations needed

Use of Standard Protocols



(a) Without standards: 12 different protocols;
24 protocol implementations



(a) With standards: 1 protocol;
7 implementations

How?

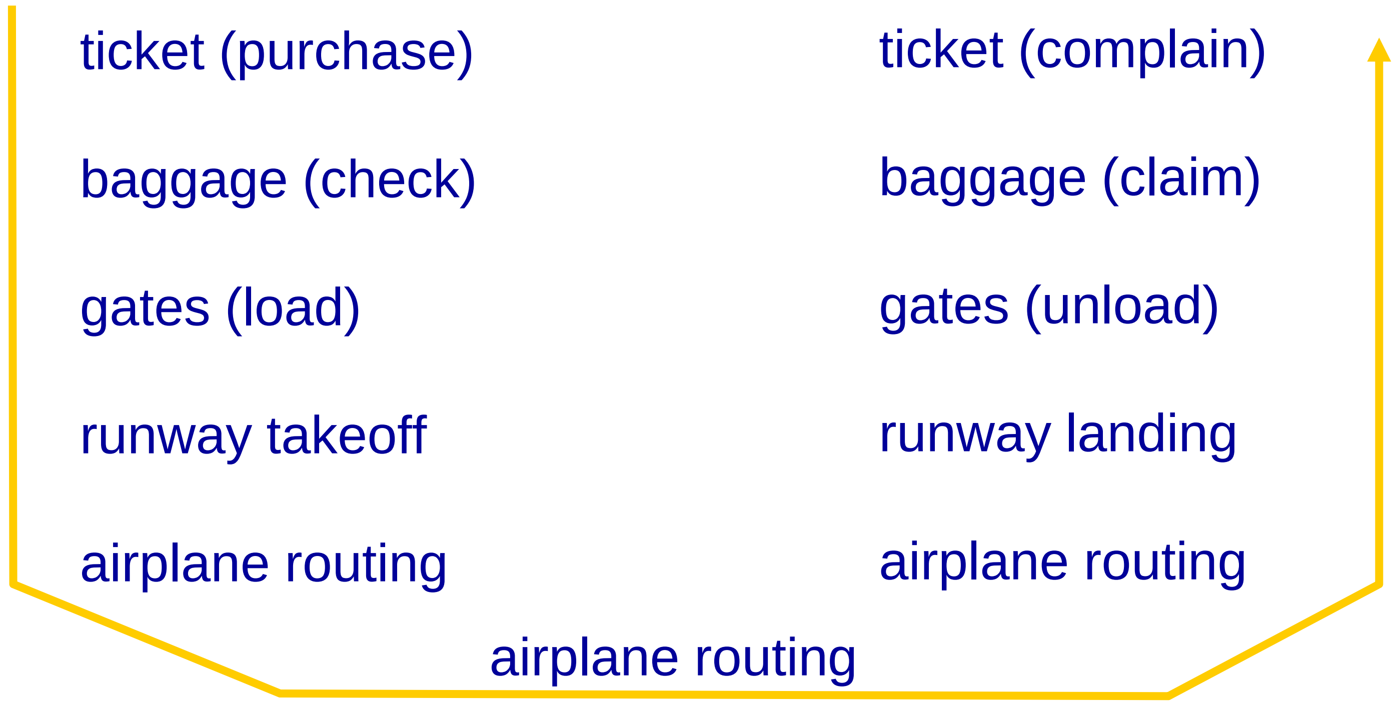
Networks are complex, with many "pieces":

- hosts
- routers
- links of various media
- applications
- protocols
- hardware, software

Question:

is there any way to *organize* structure of network?

Organization of air travel

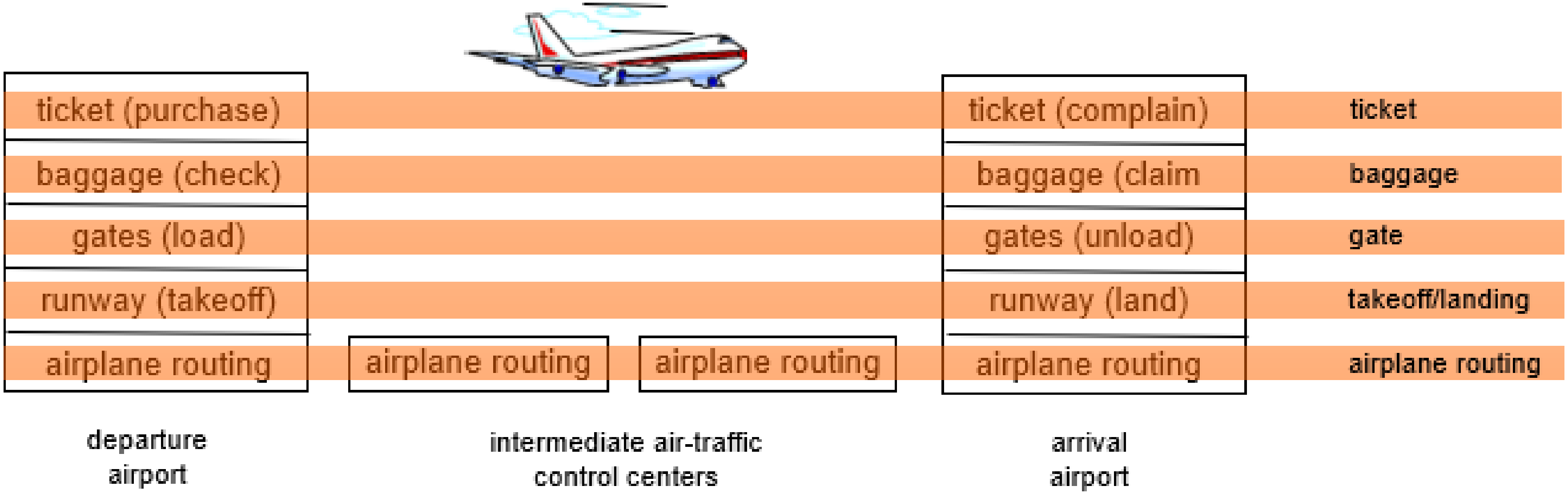


ticket (purchase)	ticket (complain)
baggage (check)	baggage (claim)
gates (load)	gates (unload)
runway takeoff	runway landing
airplane routing	airplane routing

airplane routing

- a series of steps

Layering of airline functionality



ticket (purchase)			ticket (complain)	ticket
baggage (check)			baggage (claim	baggage
gates (load)			gates (unload)	gate
runway (takeoff)			runway (land)	takeoff/landing
airplane routing	airplane routing	airplane routing	airplane routing	airplane routing
departure airport	intermediate air-traffic control centers		arrival airport	

layers: each layer implements a service

- via its own internal-layer actions
- relying on services provided by layer below/above

Why layering?

dealing with complex systems:

- explicit structure allows identification, relationship of complex system’s pieces
- modularization eases maintenance, updating of system
  - change of implementation of layer’s service transparent to rest of system
  - e.g., change in gate procedure doesn’t affect rest of system

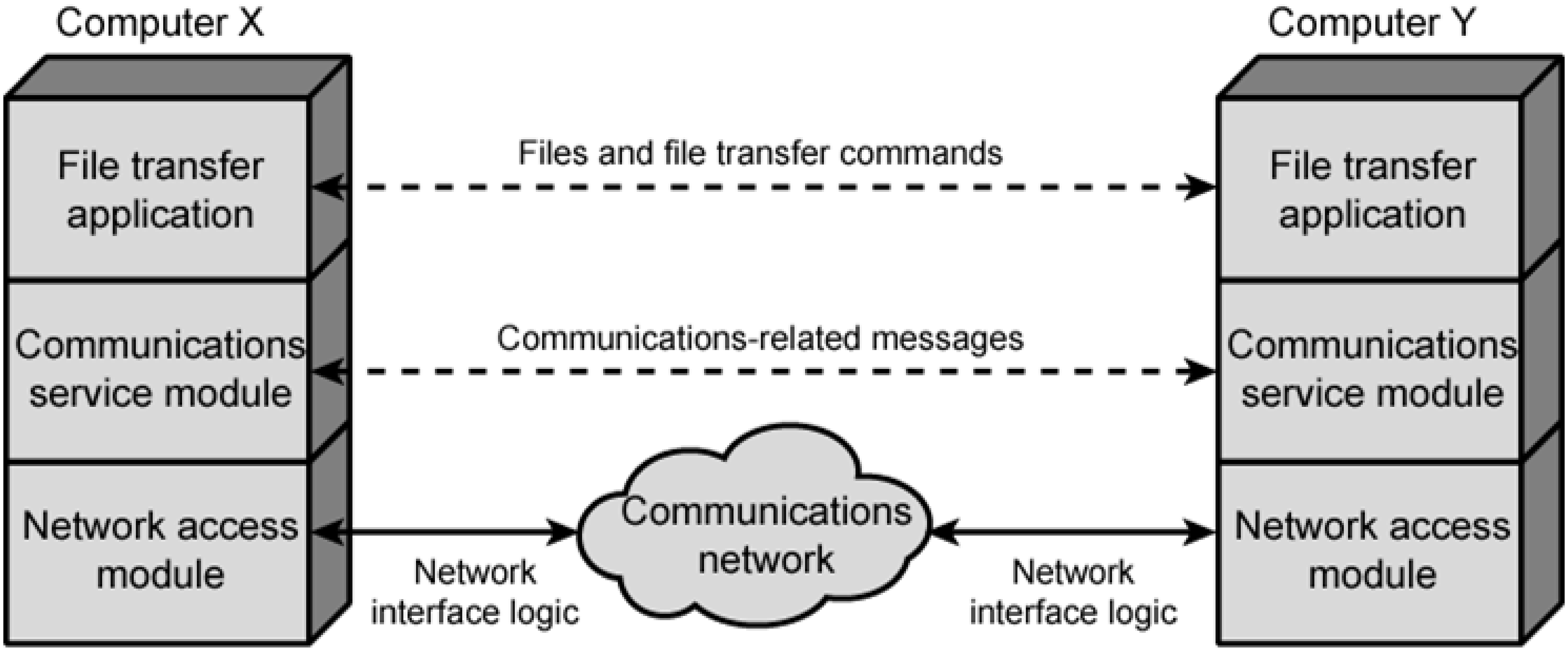
Need For Protocol Architecture

- data exchange can involve complex procedures, e.g. file transfer
- better if task broken into subtasks
- implemented separately in layers in stack
  - each layer provides functions needed to perform comms for layers above
  - using functions provided by layers below
- peer layers communicate with a protocol

Key Elements of a Protocol

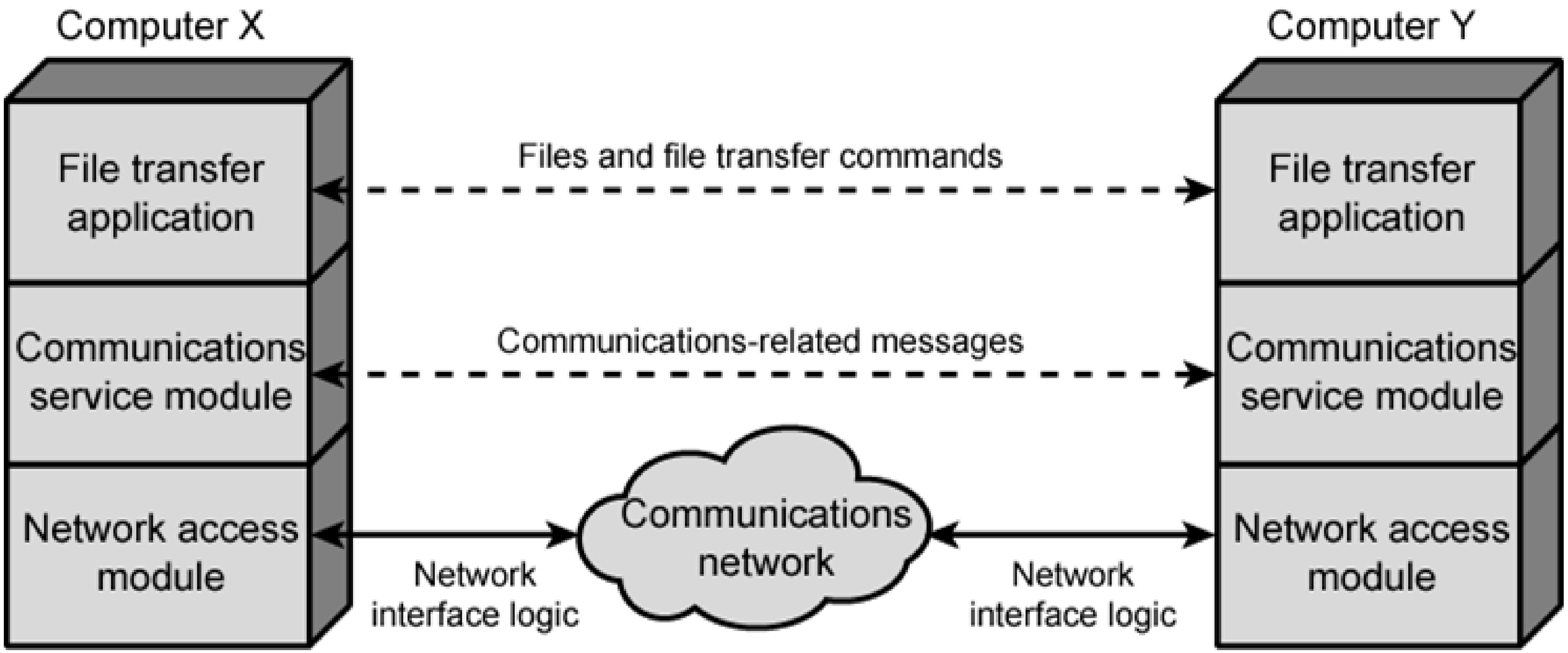
- Syntax
  - Data formats
- Semantics
  - Meaning
  - Control information
  - Error handling
- Timing
  - Speed matching
  - Sync

A Simplified File Transfer Architecture


Computer X
Computer Y
File transfer application
File transfer application
Files and file transfer commands
Communications service module
Communications service module
Communications-related messages
Network access module
Network access module
Communications network
Network interface logic
Network interface logic

A Three Layer Model

- Network Access Layer
- Transport Layer
- Application Layer



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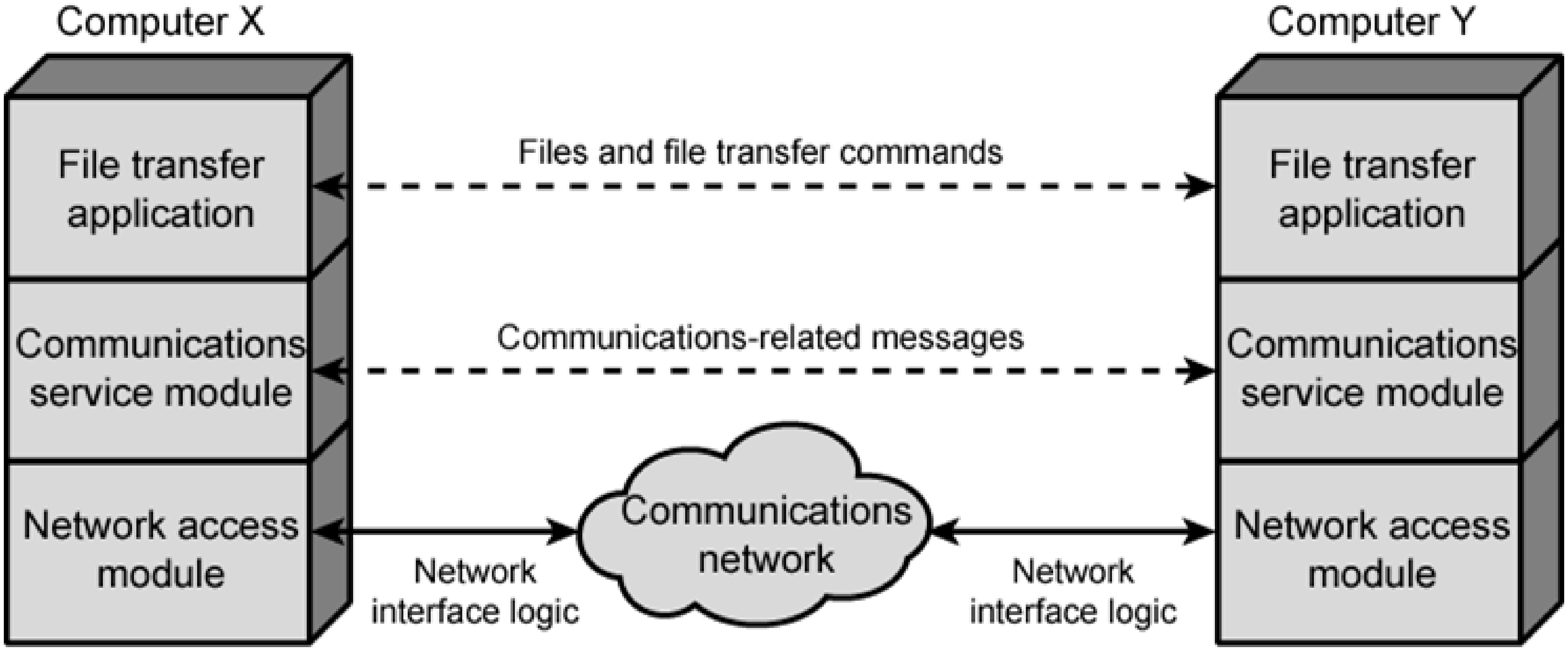
Network Access Layer

- Exchange of data between the computer and the network
- Sending computer provides address of destination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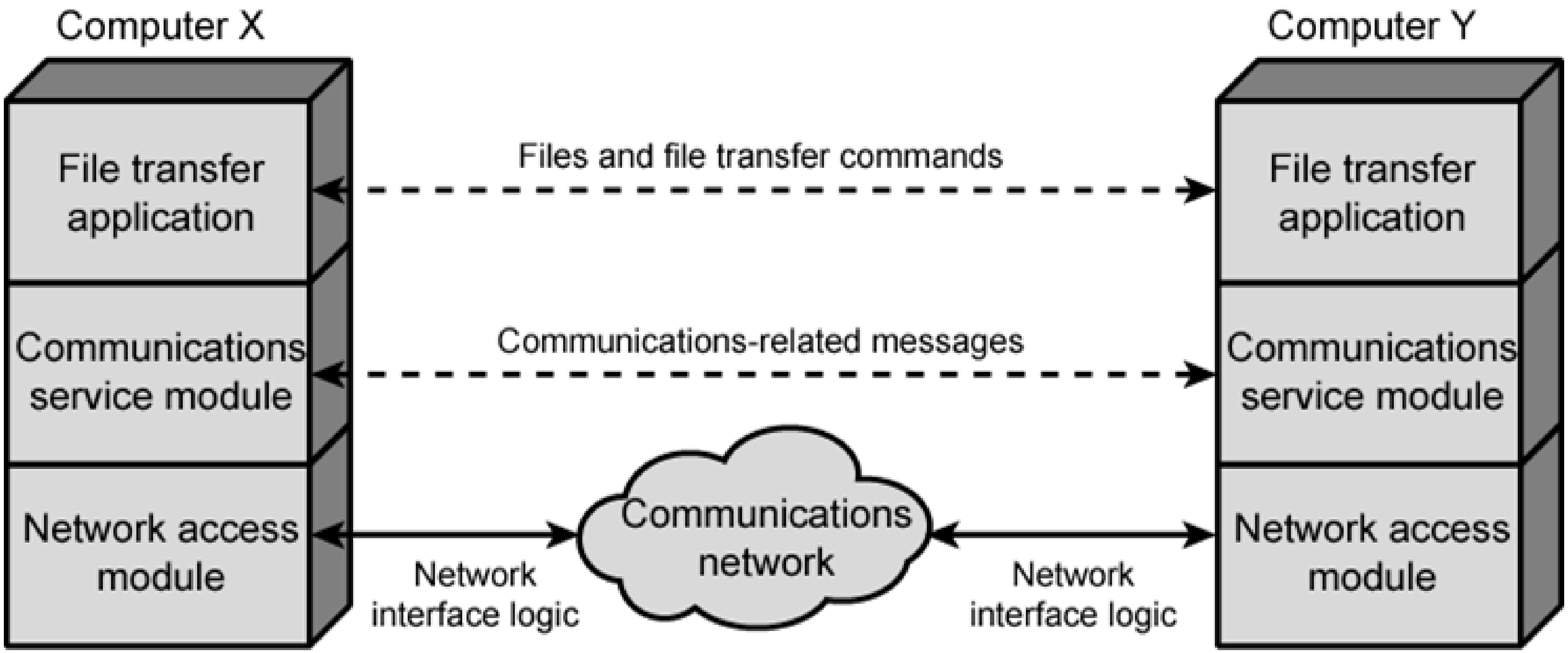
Transport Layer

- Reliable data exchange
- Independent of network being used
- Independent of application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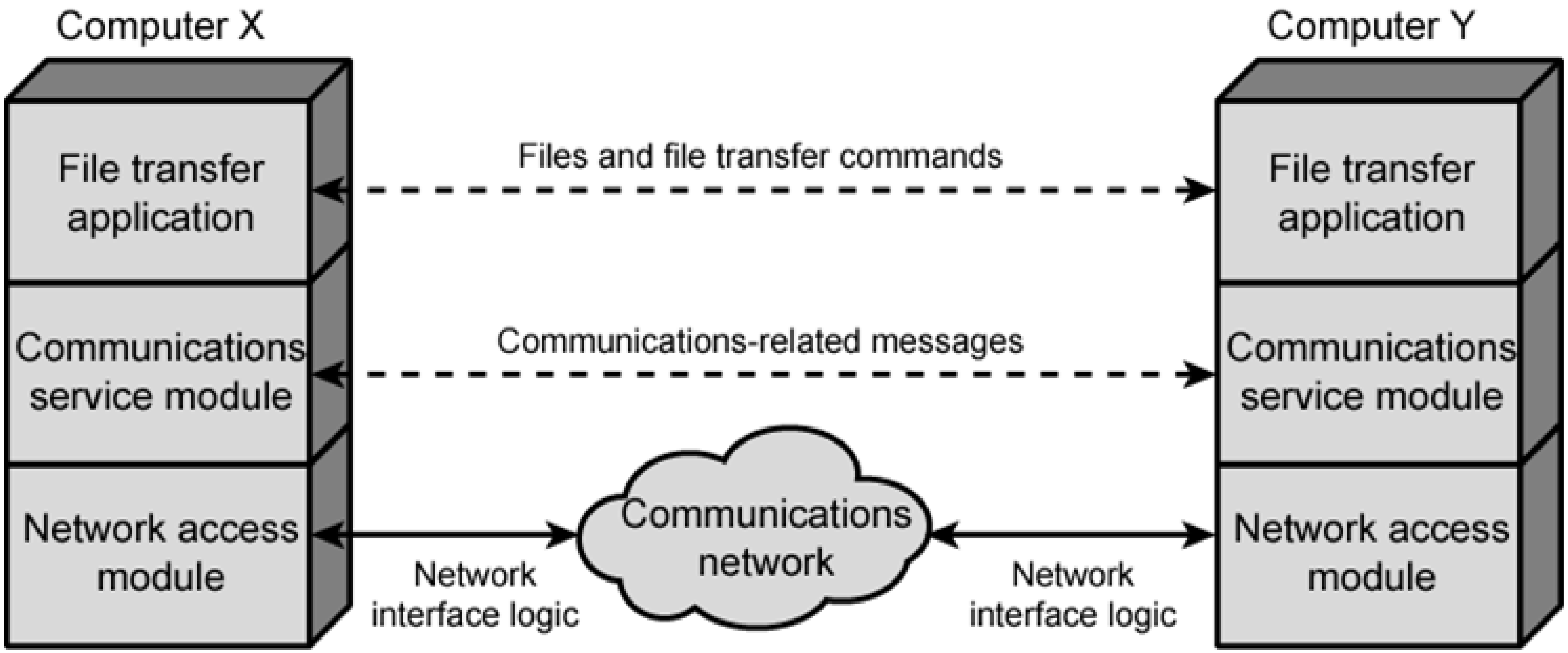
Application Layer

- Support for different user applications
- e.g. e-mail, file transfer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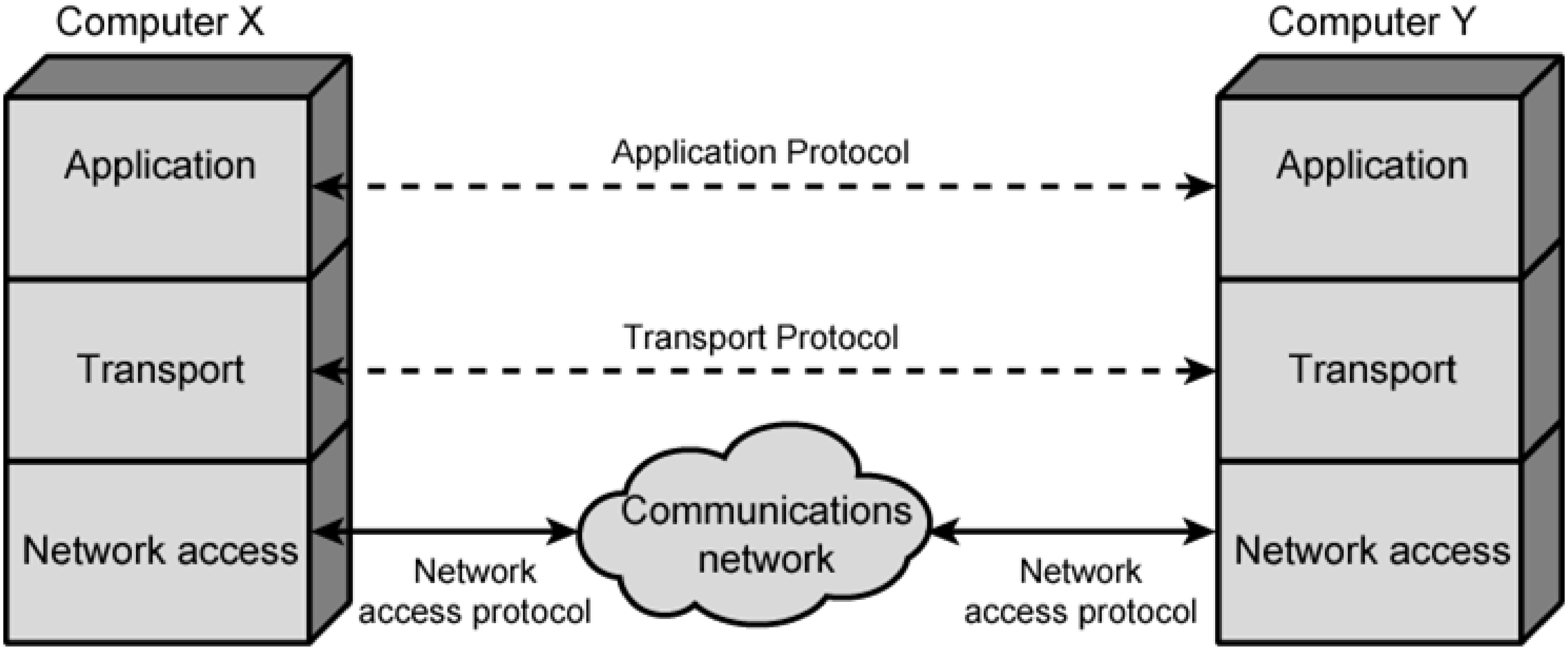
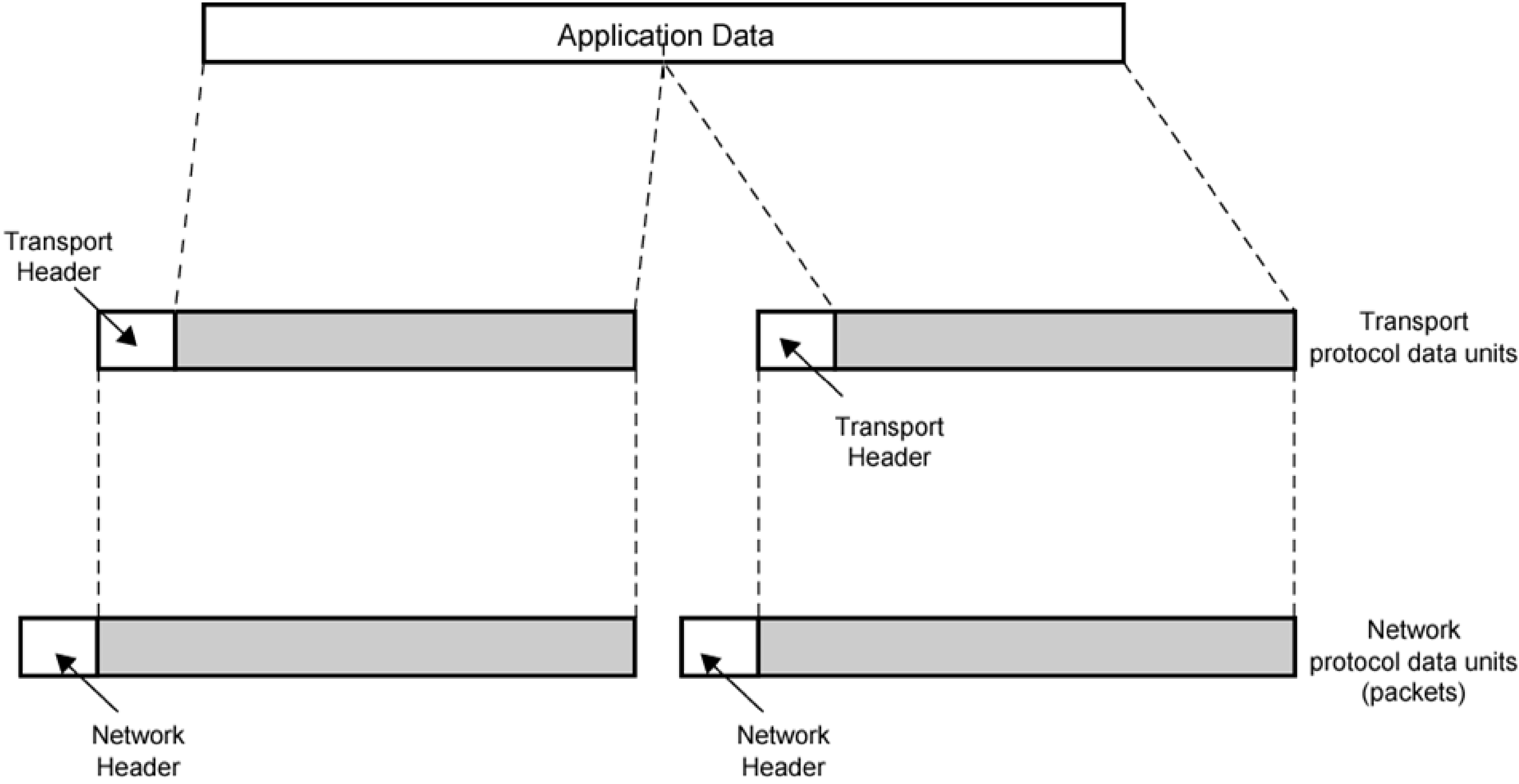
Protocols in Simplified Architecture



Protocol Data Units (PDU)

- At each layer, protocols are used to communicate
- Control information is added to user data at each layer
- e.g.
  - Transport layer may fragment user data
  - Each fragment has a transport header added
    - Destination, routing
    - Sequence number
    - Error detection code
  - This gives a transport protocol data unit

Protocol Data Units



Standardized Protocol Architectures

- Required for devices to communicate
- Vendors have more marketable products
- Customers can insist on standards based equipment
- Two standards:
  - OSI Reference model
  - TCP/IP protocol suite
    - Most widely used
- Also: IBM Systems Network Architecture (SNA)

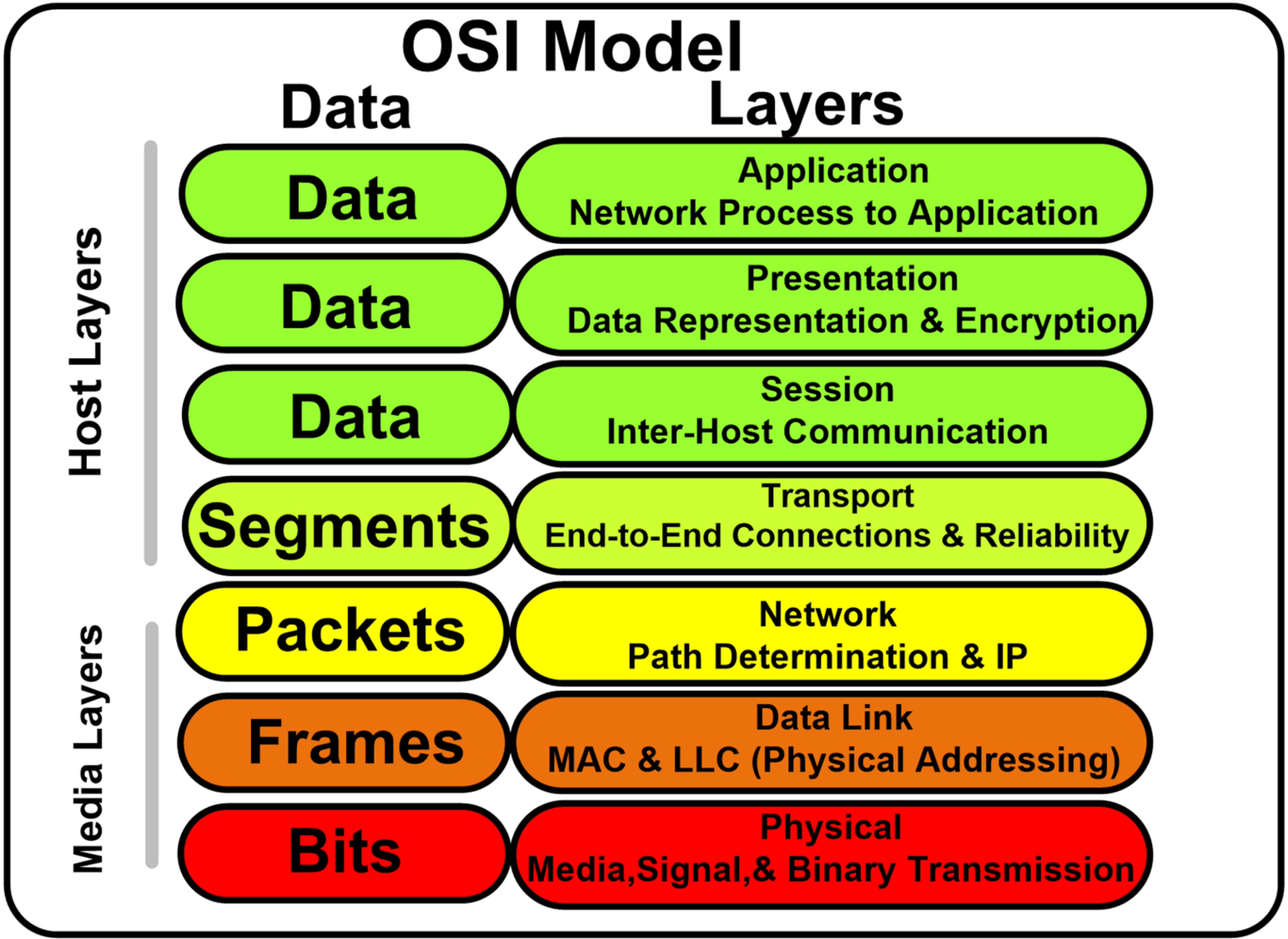
OSI Model

- Open Systems Interconnection
- Developed by the International Organization for Standardization (ISO)
- Seven layers
- TCP/IP is the de facto standard

OSI - The Model

- A layer model
- Each layer performs a subset of the required communication functions
- Each layer relies on the next lower layer to perform more primitive functions
- Each layer provides services to the next higher layer
- Changes in one layer should not require changes in other layers

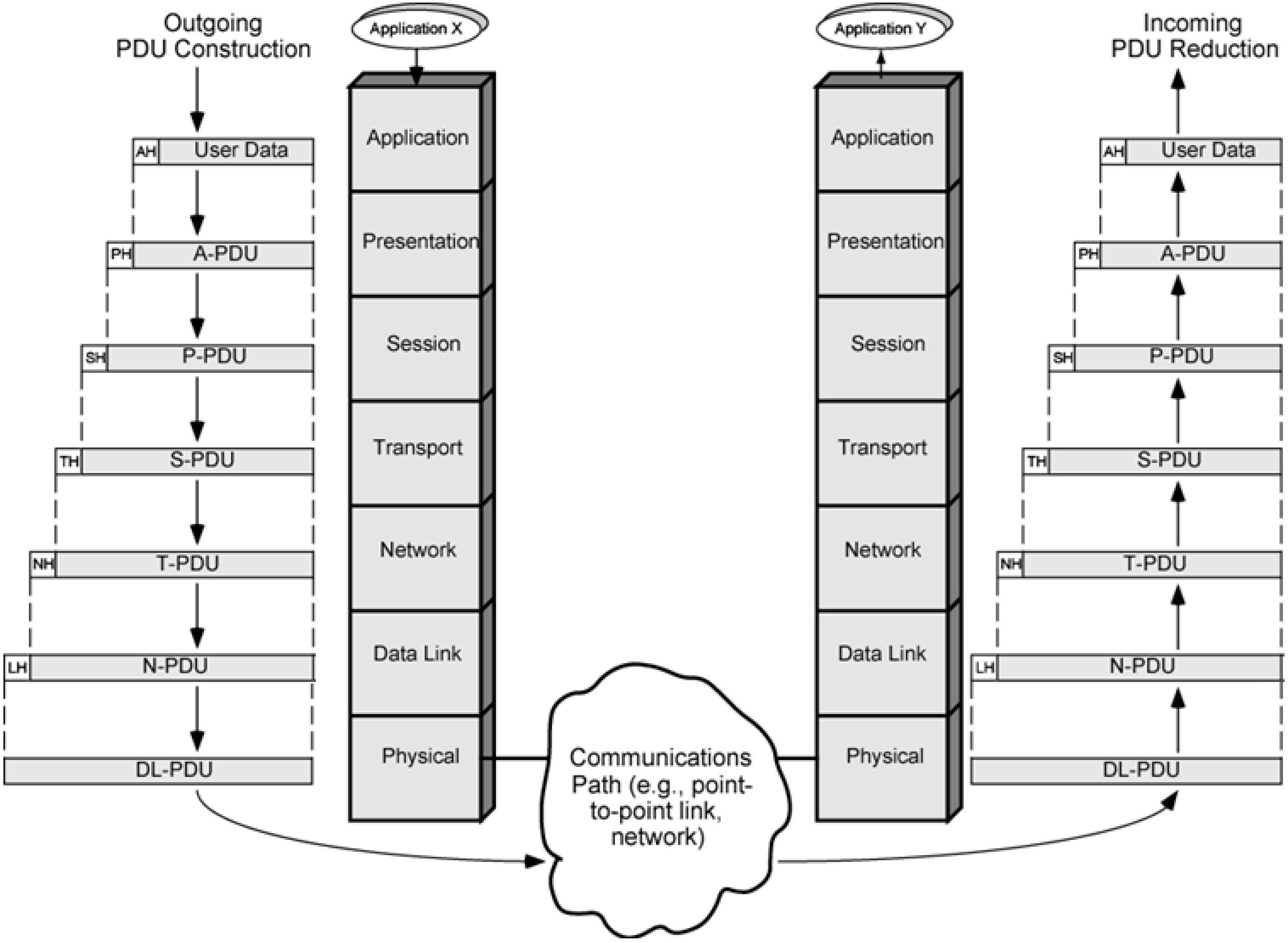
OSI Layers



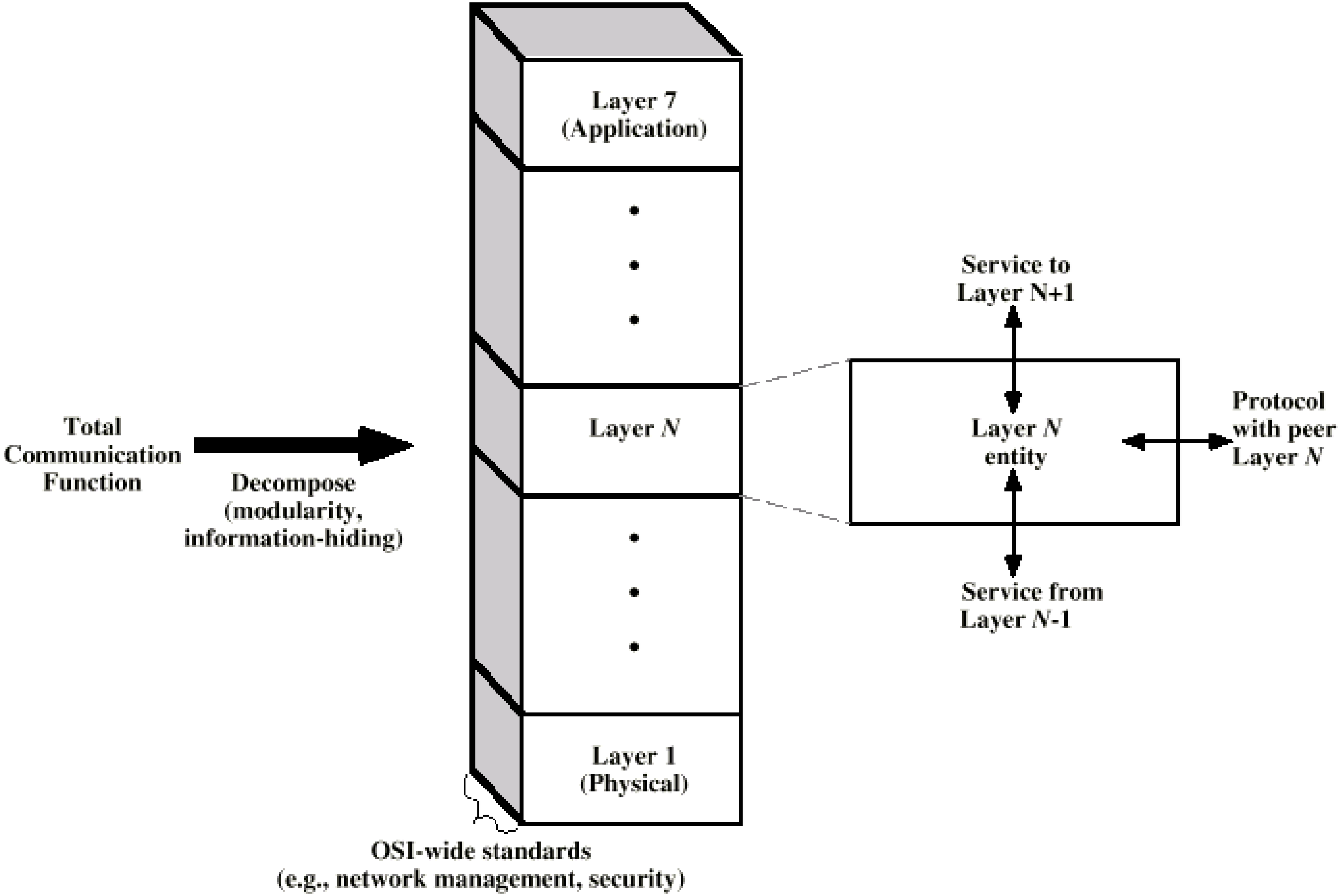
OSI Model

	Data	Layers
Host Layers	Data	Application Network Process to Application
	Data	Presentation Data Representation & Encryption
	Data	Session Inter-Host Communication
	Segments	Transport End-to-End Connections & Reliability
Media Layers	Packets	Network Path Determination & IP
	Frames	Data Link MAC & LLC (Physical Addressing)
	Bits	Physical Media,Signal,& Binary Transmission

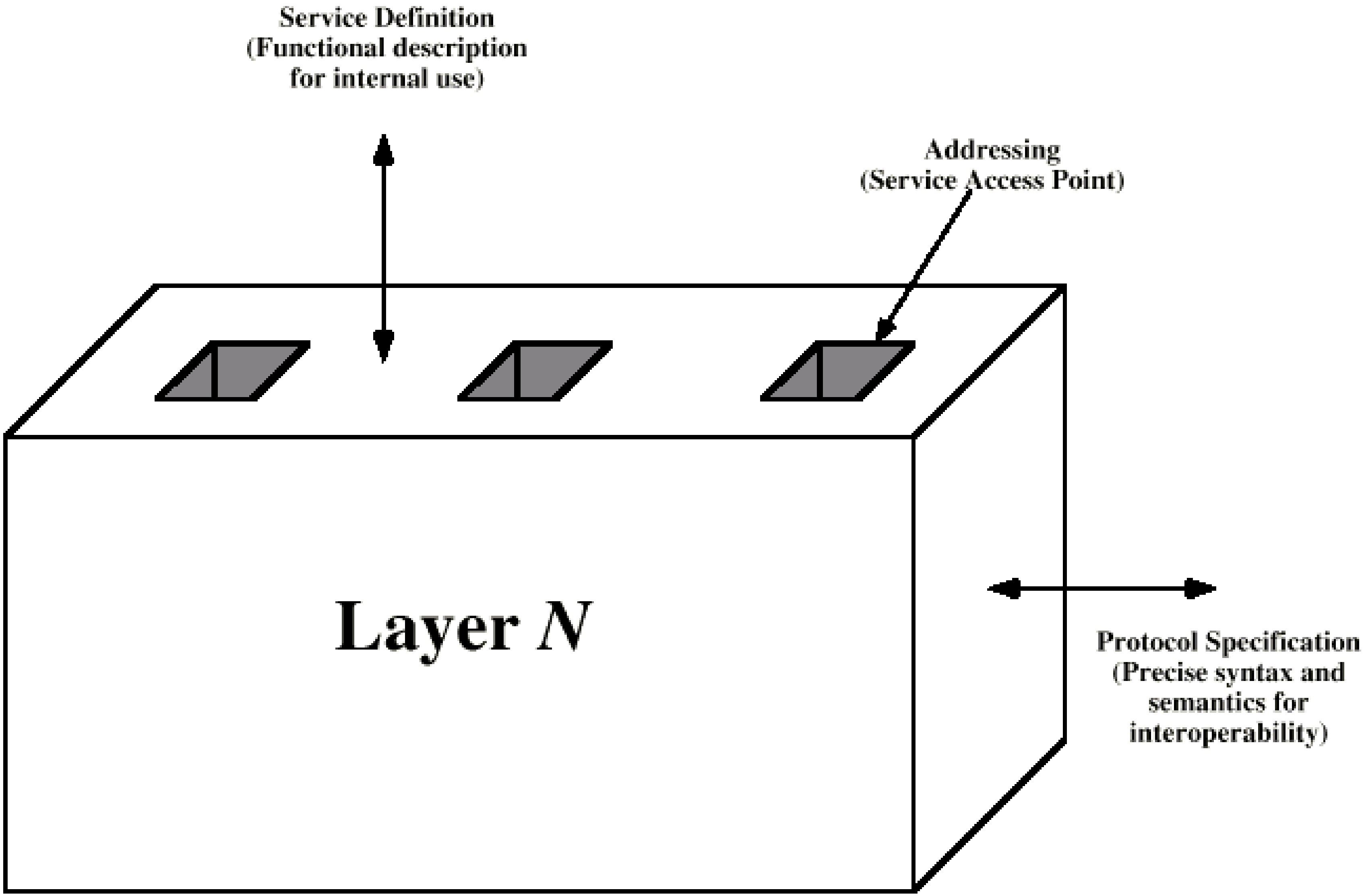
The OSI Environment



OSI as Framework for Standardization


Total Communication Function
Decompose (modularity, information-hiding)
Layer 7 (Application)
Layer *N*
Layer 1 (Physical)
OSI-wide standards (e.g., network management, security)
Service to Layer N+1
Layer *N* entity
Protocol with peer Layer *N*
Service from Layer *N*-1

Layer Specific Standards



OSI Layers (Physical Layer)

- Physical layer is the lowest layer of the OSI model. It is responsible for sending bits from one computer to another. This layer is not concerned with the meaning of the bits and deals with the setup of physical connection to the network and with transmission and reception of signals.
- Representation/Encoding of Bits: The bits must be encoded into signals for transmission.
- Data Rate
- Synchronization
- Interface
- Transmission Modes: Simplex, Half / Full Duplex

OSI Layers (Data Link)

- Data link layer performs the most reliable **node to node** delivery of data.
- It create frames from the packets that are received from network layer and gives it to physical layer.
- Flow Control
- Error detection and control
- Access Control
- Higher layers may assume error free transmission

OSI Layers (Network Layer)

- The main aim of this layer is to deliver packets from source to destination across multiple links (networks). If two computers (system) are connected on the same link, then there is no need for a network layer.
- Transport of information
- Routers and gateways operate in the network layer.
- Higher layers do not need to know about underlying technology

OSI Layers (Transport Layer)

- Segmentation and Reassembling
- Connection Control:
  - Connectionless
  - Connection Oriented
- Flow Control: In this layer, flow control is performed **end to end**.
- Error Control: Error Control is performed **end to end** in this layer to ensure that the complete message arrives at the receiving transport layer without any error. Error Correction is done through retransmission.
- Quality of service

OSI Layers

- **Session Layer**
  - Control of dialogues between applications
  - Dialogue discipline
  - The Session Layer allows users on different machines to establish active communication sessions between them.
- **Presentation Layer**
  - Data formats and coding
  - Data compression
  - Encryption
- **Application Layer**
  - It is the top most layer of OSI Model. It enables user or software to get access to the network.
  - Means for applications to access OSI environment

TCP/IP Protocol Architecture

- Developed by the US Defense Advanced Research Project Agency (DARPA) for its packet switched network (ARPANET)
- Used by the global Internet
- No official model but a working one.
  - Application layer
  - Host to host or transport layer
  - Internet layer
  - Network access layer
  - Physical layer

Physical Layer

- **Definition of Hardware Specifications**: The details of operation of cables, connectors, wireless radio transceivers, network interface cards etc.
- **Encoding and Signaling**: The physical layer is responsible for various encoding and signaling.
- **Data Transmission and Reception**: After encoding the data appropriately, the physical layer actually transmits the data, and of course, receives it.
- **Topology and Physical Network Design**

Network Access Layer

- Exchange of data between end system and network
- Destination address provision
- Invoking services like priority

Internet Layer (IP)

- The internet layer provides procedures used to allow data to traverse multiple interconnected networks, to provide communications between devices are attached to different networks.
- The Internet Protocol (IP) is used at this layer to provide the **routing function** across multiple networks.
- This protocol is implemented **not only in the end systems but also in routers**.
- A router is a processor that connects two networks and whose primary function is to relay data from one network to the other on its route from the source to the destination end system.

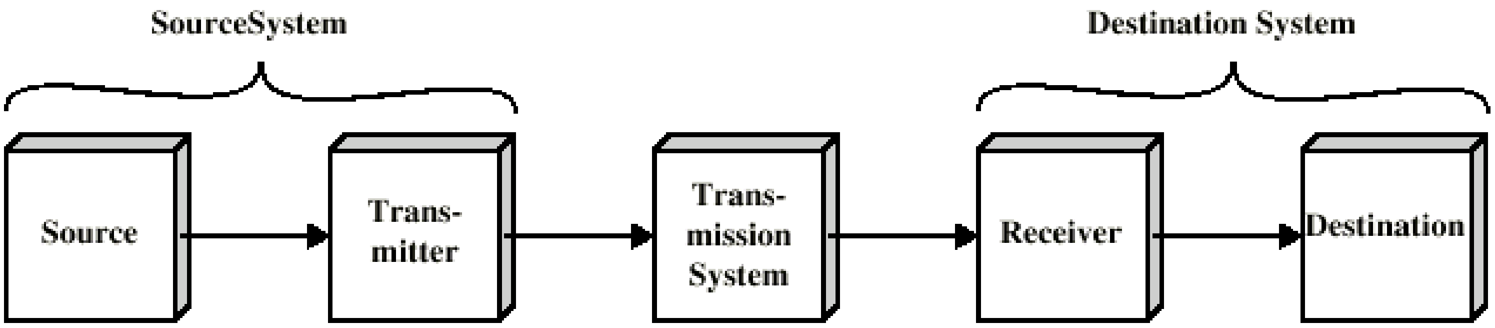
Transport Layer (TCP)

- The host-to-host layer, or transport layer, provide **reliable delivery** of data.
- Regardless of the nature of the applications, there is usually a requirement that data be exchanged reliably, ensuring that all of the data arrives at the destination application and that the **data arrives in the same order** in which they were sent.
- These mechanisms for providing reliability are essentially independent of the nature of the applications.
- The Transmission Control Protocol (TCP) is the most commonly used protocol to provide this functionality.

Application Layer

- The application layer contains the logic needed to support the various user applications. For each different type of application, such as file transfer, a separate module is needed that is peculiar to that application.
- A number of applications have been standardized to operate on top of TCP.
- e.g.
  - http
  - Simple Mail Transfer Protocol (SMTP)
  - File Transfer Protocol (FTP)

TCP/IP Protocol Architecture Model



SourceSystem

Destination System

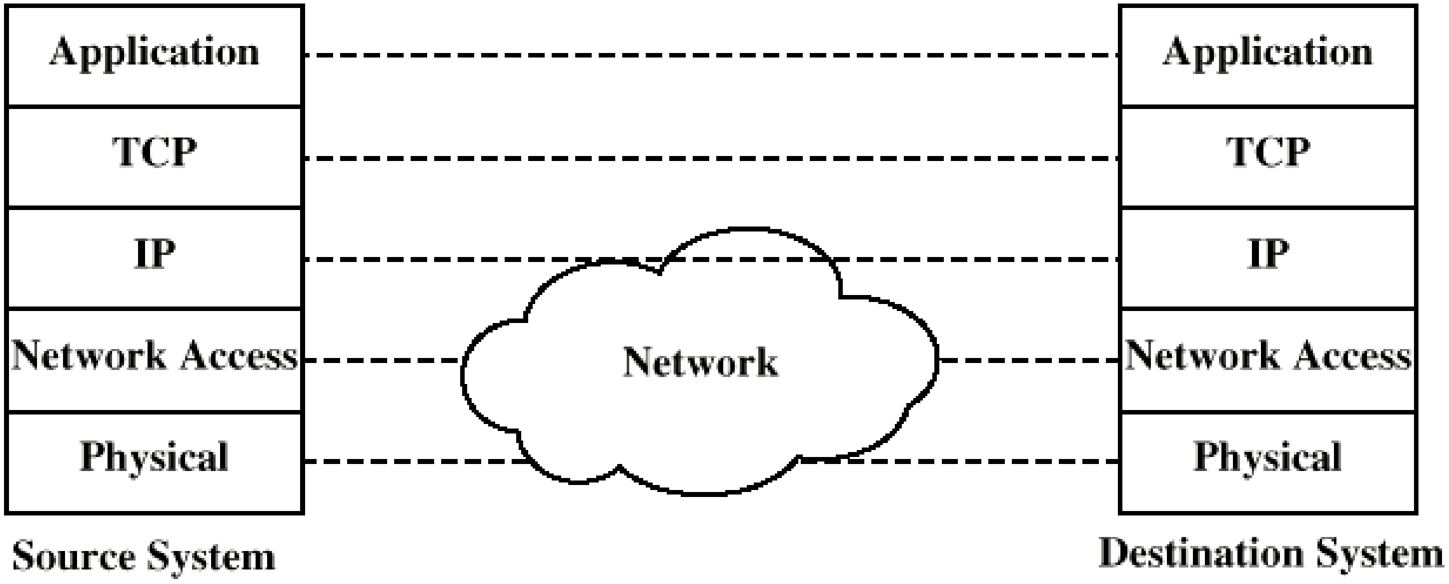
Source

Trans-
mitter

Trans-
mission
System

Receiver

Destination



Application

TCP

IP

Network Access

Physical

Network

Application

TCP

IP

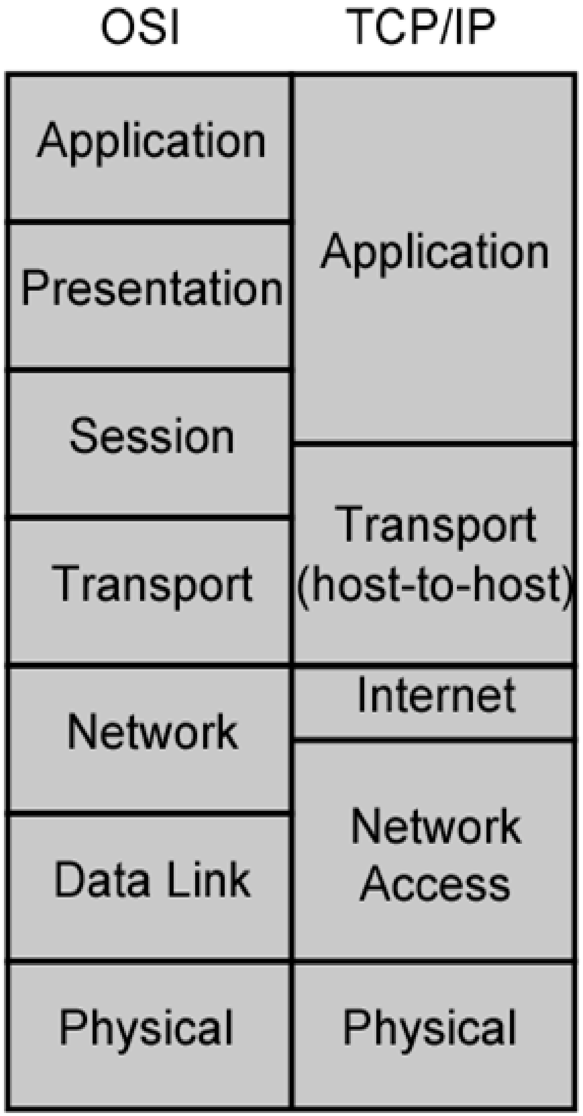
Network Access

Physical

Source System

Destination System

OSI v TCP/IP



OSI

TCP/IP

Application

Presentation

Session

Transport

Network

Data Link

Physical

Application

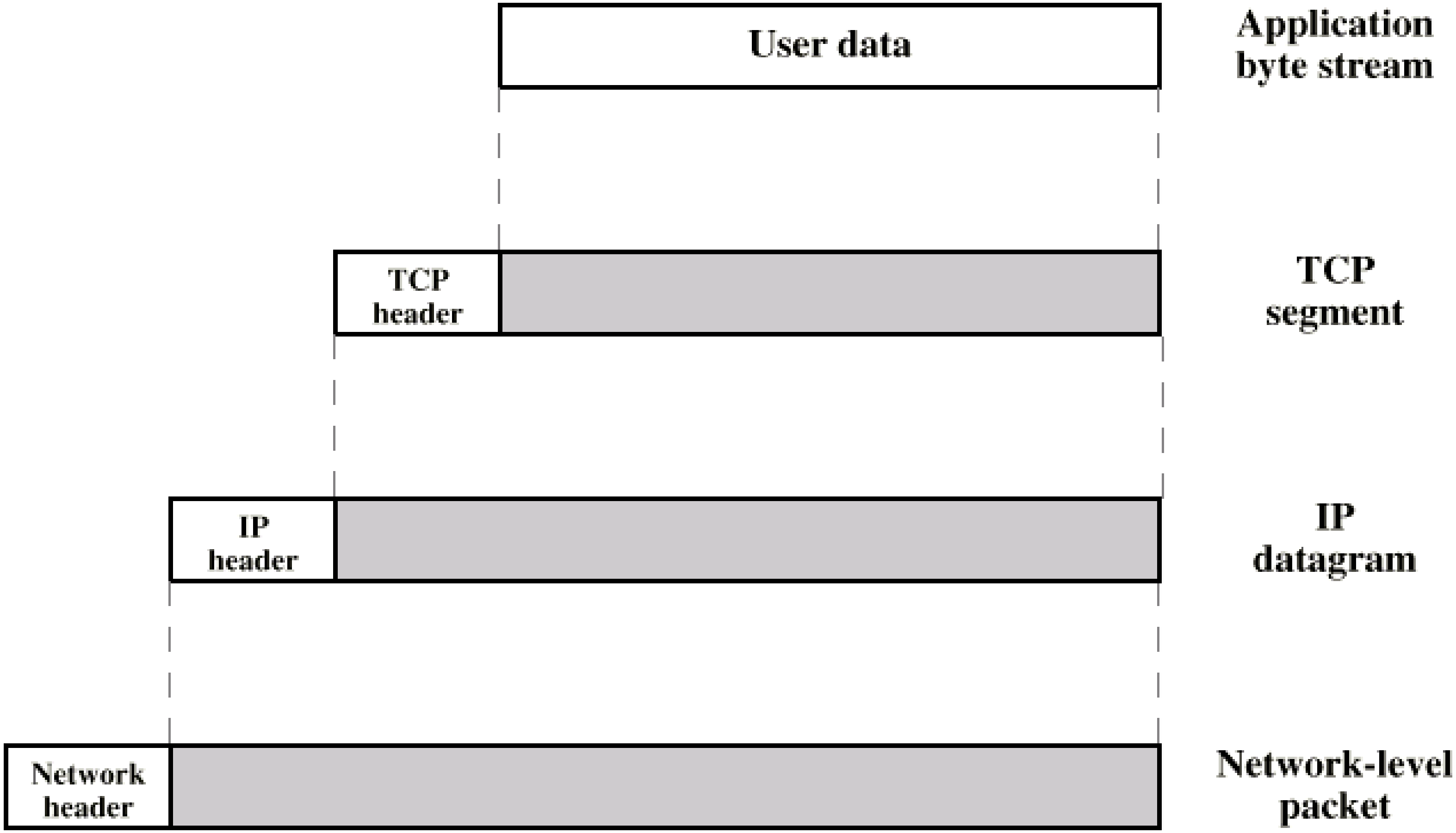
Transport (host-to-host)

Internet

Network Access

Physical

PDUs in TCP/IP



Addressing Requirements

- two levels of addressing required
- each host on a subnet needs a unique global network address
  - its IP address
- each application on a (multi-tasking) host needs a unique address within the host
  - known as a port